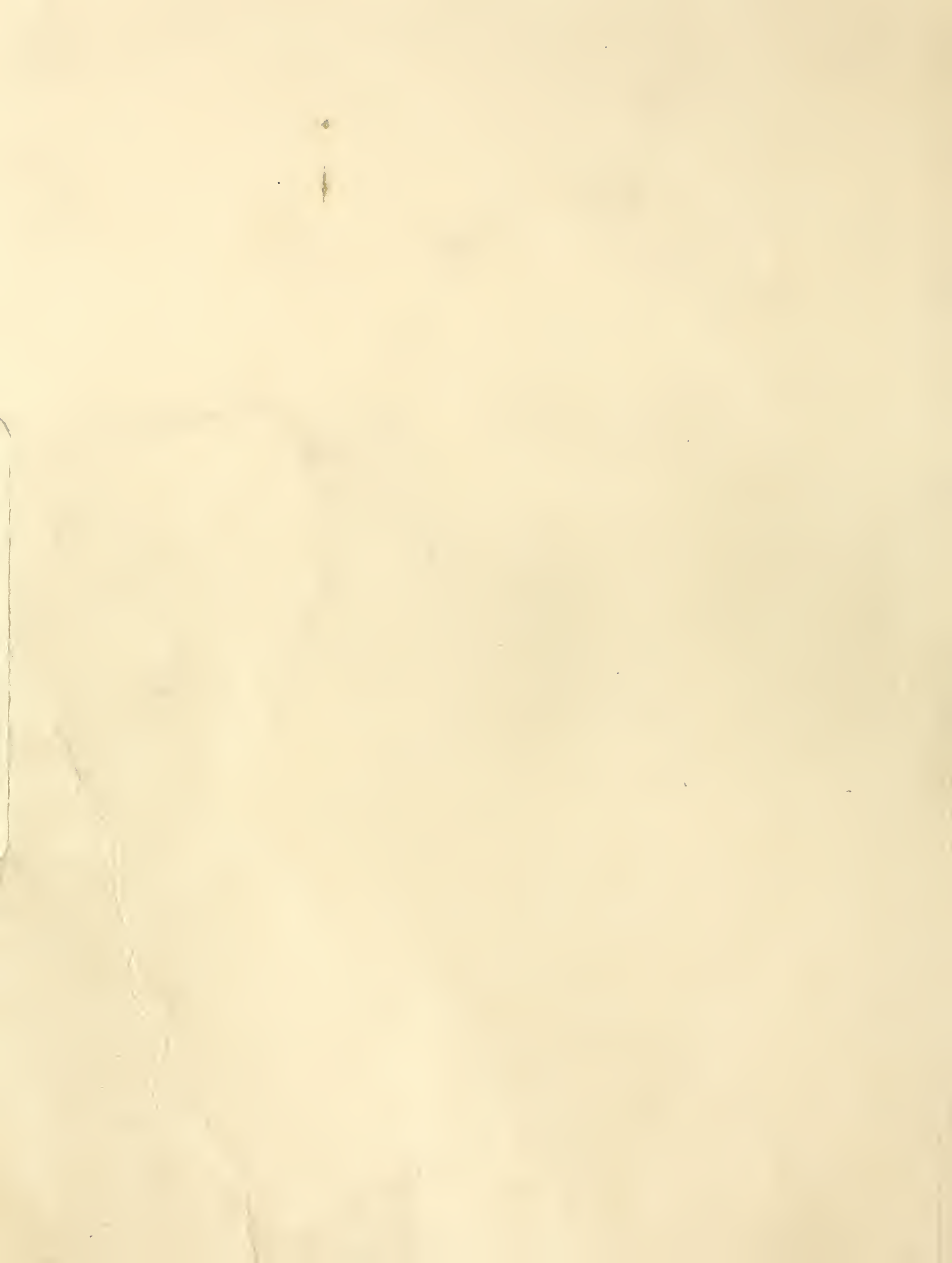


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USDA Forest Service

Rocky Mountain Forest and
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Permanent Plots for Quantifying Damage Caused by Western Dwarf Mistletoes and Their Spread and Intensification

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This note describes 40 permanent plot installations in the West that have been established to monitor the effects of dwarf mistletoes (*Arceuthobium* spp.) on growth and mortality in infested conifer stands or to quantify spread and intensification of the parasites. The distribution of the plots by host species is: interior ponderosa pine (11), coastal ponderosa pine and Jeffrey pine (10), lodgepole pine (5), Douglas-fir (6), true firs (4), western larch (2), western hemlock (1), and spruce (1).

Keywords: Dwarf mistletoe, *Arceuthobium*, damage, spread, intensification.

This compilation, which we initiated after a 1989 meeting that involved various units of the Forest Service, U.S. Department of Agriculture, lists the active permanent plots in the West that are available to: (1) monitor the spread and intensification of dwarf mistletoes, and/or (2) quantify the effects of these pathogens on the mortality, growth, and yield of trees or stands. The plots are listed by dwarf mistletoe and host species, and the unit that established the study or is maintaining the plot records is indicated. Also, publications or reports relating to each plot installation are given. This information should be useful to those attempting to develop and calibrate growth and yield models for dwarf mistletoe-infested stands in the West.

When new plots are established, consideration should be given to meeting the standards for permanent plots as described by the USDA Forest Service (1989), although additional dwarf mistletoe information is needed.

In addition to the plots described here, permanent Forest Inventory plots may provide information on dwarf mistletoe intensification and damage in some areas (Bolsinger 1978).

- I. ARCEUTHOBIUM VAGINATUM ssp. CRYPTOPODUM ON INTERIOR PONDEROSA PINE (PINUS PONDEROSA var. SCOPULORUM)

¹Plant Pathologist and Biometrician, Rocky Mountain Forest and Range Experiment Station. Headquarters is in Fort Collins, in cooperation with Colorado State University.

1. Fort Valley Experimental Forest, Arizona: 24 plots with 3 growing stock levels (60, 80, and 100 square feet per acre) × 2 replicates and 4 intensities of dwarf mistletoe infection in a 60-year-old, even-aged stand. (Note: 2 plots were destroyed by fire.) Established in 1978-79, measured in 1983 and 1988. Rocky Mountain Station. Reference: Hawksworth and Geils (1985).
2. Fort Valley Experimental Forest, Arizona: 9 treated plots (each 25 acres) plus 3 untreated plots (each 10 acres) in virgin ponderosa pine; 3 dwarf mistletoe treatments (limited, unlimited, and light improvement selection) × 3 replicates. Established in 1952, last examined in 1977. The 225-acre treated area was logged after the 1977 examination, but the 3 check plots remain undisturbed. Rocky Mountain Station. References: Heidmann (1968, 1983), Herman (1961).
3. Fort Valley Experimental Forest, Arizona: 3 plots totalling 19 acres in uneven-aged ponderosa pine; sanitized by pruning and felling in 1933. Examined in 1950 and 1970. Rocky Mountain Station. Reference: Gill and Hawksworth (1954).
4. Fort Valley Experimental Forest, Arizona: 16 plots (2.5 acres) in a virgin ponderosa pine stand (G. A. Pearson Natural Area); 3,000 in-

dividual trees evaluated at 5-year intervals from 1920 to 1970. The records include dwarf mistletoe but the infestation is light (range from no infection to 6% of the trees infected on the 2.5 acre plots in 1920). Rocky Mountain Station and Northern Arizona University. References: Avery et al. (1976), Linhart (1988).

5. Grand Canyon National Park, Arizona: 7 plots (4 treated and 3 untreated) totalling 35 acres, in uneven-aged and even-aged ponderosa pine. Established in 1950–52, examined in 1955, 1961, 1970, and 1982 (also 1 plot examined in 1988); next examination planned for 1990. Rocky Mountain Station. References: Dixon and Hawksworth (1979), Hawksworth and Geils (1990), Lightle and Hawksworth (1973), Maffei (1984).
6. Mescalero Apache Reservation, New Mexico: 7 plots totalling 64 acres in even-aged and uneven-aged ponderosa pine. Established in 1945–1951, examined in 1955, 1961, 1970, and 1982; next examination planned for 1990. Rocky Mountain Station. Reference: Hawksworth and Lusher (1956).
7. Bryce Canyon National Park, Utah: 5 plots totalling 6 acres in uneven-aged ponderosa pine and mixed limber pine (*Pinus flexilis*)-bristlecone pine (*P. longaeva*)-ponderosa pine types (1 plot destroyed by park development). Established in 1952, last examined in 1987. Rocky Mountain Station. References: none.
8. Manitou Experimental Forest, Colorado: 30 plots (0.1–0.4 acre) in even-aged ponderosa pine pole stands; thinned to various growing stock levels in 1978. Last measured in 1988. Rocky Mountain Station. References: none.
9. Manitou Experimental Forest, Colorado: 20 plots (1–2.5 acres) in mature uneven-aged ponderosa pine; various silvicultural applications, including no treatment. Established in 1978, last measured in 1988. Rocky Mountain Station. Reference: Maffei (1989).
10. Roosevelt National Forest, Colorado: 30 plots (0.1–0.4 acre) in even-aged pole stands; thinned to various growing stock levels in 1978–79. Last examined in 1988–89. Rocky Mountain Station. References: none.
11. Apache-Sitgreaves National Forest, Arizona: 553 ponderosa pines tagged in 1979 in virgin mixed-conifer stands on the 1,800-acre Willow-Thomas Creek Watershed. Trees were rerated for dwarf mistletoe in 1989. Rocky Mountain Station. Reference: Gottfried (1978).

II. ARCEUTHOBIVM CAMPYLOPODUM ON COASTAL PONDEROSA PINE (PINUS PONDEROSA var. PONDEROSA) AND JEFFREY PINE (PINUS JEFFREYI)

1. Eastern Washington State Lands: 32 plots (0.1-acre) in even-aged pole stands. Most plots are in pure ponderosa pine but about one-fifth are mixed ponderosa pine-Douglas-fir. The

Douglas-fir is also infected by dwarf mistletoe. Trees of both species were thinned and sanitized for dwarf mistletoe in 1974. Plots were remeasured in 1979 and in 1986. Ken Russell, Washington Department of Natural Resources, Olympia. References: Russell (1980, 1987).

2. Eastern Oregon National Forests: 6 thinning plots in even-aged ponderosa pine established in 4 areas in 3 national forests—Hahn Springs on the Ochoco National Forest (1 plot with 53 trees measured in 1976 and 1982), 2 plots on the Malheur National Forest (Fawn Creek with 90 trees measured in 1970, 1975, and 1982 and Sunshine with 100 trees measured in 1970, 1975, and 1982), and 3 plots near Beatty in the Fremont National Forest (with 95, 89, and 98 trees measured in 1970–72, 1975, and 1982). Plots established by the Pacific Northwest Forest and Range Experiment Station; now maintained by Region 6, Forest Pest Management. Summary of data from all plots made by Tom Gregg of Region 6, Forest Pest Management, in 1984. Copies of tree records also at Rocky Mountain Station. References: none.
3. Pringle Falls Experimental Forest, Oregon: 48 plots (0.22-acre) (4 thinning levels \times 12 replicates) established by Lew Roth of Oregon State University in 1966; mistletoe data recorded annually between 1966 and 1980, tree data recorded in 1968, 1976, and 1988. Assistance in the analyses of the 1988 readings being provided by the Rocky Mountain Station. References: none.
4. Pringle Falls Experimental Forest, Oregon: 6 plots (0.19-acre) established by Lew Roth of Oregon State University in mature ponderosa pine with a sapling understory in 1957; infected overstory removed and understory thinned to 48 trees per plot (250 trees per acre). Plots measured in 1959 and 1969. Pacific Northwest Station. References: Barrett and Roth (1985), Roth and Barrett (1985).
5. Pringle Falls Experimental Forest, Oregon: an outplanting in 3 replications testing the resistance to dwarf mistletoe of each of 12 parent ponderosa pine trees presumably differing in resistance to dwarf mistletoe. Established in 1969 by Lew Roth of Oregon State University. Mistletoe data and tree measurements recorded in 1989. References: none.
6. Eastside Oregon and Washington: thinning plots established in ponderosa pine in central and eastern Washington and Oregon; thinning levels were 82, 128, and 174 trees per acre, which equated to 45, 70, and 95 square feet of basal area per acre based on an average d.b.h. of 10 inches, respectively. A total of 141 plots established; 27, 39, 62, and 13 plots measured for baseline data in 1980, 1981, 1982, and 1983, respectively. First 5-year measurement taken in 1985, 1986, 1987, and 1988. Plots established

by the Pacific Northwest Station, and 5-year records taken by Forest Pest Management, Region 6. Data are on file at the National Computer Center at Fort Collins but are not yet analyzed. References: none.

7. California and Nevada Recreational Areas: 526 tagged ponderosa pine and Jeffrey pines in 3 campgrounds on the Lassen National Forest, California; 1,545 tagged Jeffrey pines at the Nevada Beach Campground, Tahoe National Forest, Nevada, and 974 tagged Jeffrey pines at Laguna Mountain Campground, Cleveland National Forest, California. Established in 1973–74 to monitor mortality in mistletoe-infected trees and changes in mistletoe intensification. Pacific Southwest Region and Pacific Southwest Station. References: Scharpf and Vogler (1986), Scharpf et al. (1988); Vogler and Scharpf (1981).
8. Lassen National Forest, California: 7 plots (1–3 acres) established in the Manzanita Chute area in 1964 to monitor spread and intensification of dwarf mistletoe in understory Jeffrey pines. Pacific Southwest Station. References: Parmeter and Scharpf (1972), Scharpf and Parmeter (1971).
9. Lassen National Forest, California: 7 plots (1-acre) established in 1979 at Grays Valley, Eagle Lake Ranger District, to measure the effects of thinnings to various densities in mistletoe-infested ponderosa pine. Pacific Southwest Region, Forest Pest Management. Reference: Fiddler et al. (in prep.).
10. Sierra Nevada, California and Nevada: 4 Jeffrey pine progeny tests were established in 1940 by the Institute of Forest Genetics. These are now being used to quantify resistance to *Arceuthobium campylopodum*. Pacific Southwest Station. Reference: Scharpf (1987).

III. *ARCEUTHOBIUM AMERICANUM* ON LODGEPOLE PINE (*PINUS CONTORTA* var. *LATIFOLIA*)

1. Targee National Forest, Idaho: 16 plots (0.1–0.2 acre) in even-aged pole stands; thinned to various spacings in 1983. Last measured in 1988. J. Hoffman, Intermountain Region, Boise; assistance in the 1988 re-examination provided by the Rocky Mountain Station. References: none
2. Gallatin National Forest, Montana: 36 plots (0.5-acre) in even-aged pole stands; 3 dwarf mistletoe treatments \times 4 thinning levels \times 3 replicates. Established in 1971, remeasured in 1984 and 1989. Remeasurements made in 1989 by the Rocky Mountain Region and Rocky Mountain Station. Northern Rocky Mountain Region. References: Dooling et al. (1986), Johnson et al. (1986).
3. Fraser Experimental Forest, Colorado: 28 plots (0.4-acre) in even-aged, 60- to 70-year-old, pole-sized stands; thinned to various growing stock levels (40, 80, 100, 120, and 160) in

1976–1981. Plots remeasured at 5-year intervals. Rocky Mountain Station, Multiresource Management and Pest Assessment Technology Projects. References: Alexander and Edminster (1981), Alexander et al. (1985).

4. Roosevelt National Forest, Colorado: 19 plots (0.3–1.0 acre) near Pingree Park in even-aged pole stands, thinned to various levels in 1949–1981. Last remeasured in 1987. Colorado State University and Rocky Mountain Station. References: none.
 5. Routt National Forest, Colorado: 37 plots (0.5-acre) in even-aged pole stands; sanitized for dwarf mistletoe and thinned in 1965–66. Last remeasured in 1987. Rocky Mountain Station and Rocky Mountain Region. References: Hawksworth et al. (1977, 1987).
- ### IV. *ARCEUTHOBIUM DOUGLASII* ON DOUGLAS-FIR (*PSEUDOTSUGA MENZIESII* var. *GLAUCA*)
1. Lolo National Forest, Montana: 25 plots (0.25-acre) in even-aged pole stands; 3 dwarf mistletoe treatments \times 4 thinning levels \times 2 replicates, plus 1 extra plot. Established in 1970, remeasured in 1983 and 1988. Northern Rocky Mountain Region. Reference: Dooling et al. (1986).
 2. Okanogan and Malheur National Forests: study of response of pole-sized Douglas-fir and dwarf mistletoe to thinning; 9 plots with 227 trees established on the Malheur National Forest, Oregon, in 1973, remeasured in 1983 and 1988; 6 plots with 144 trees established on the Okanogan National Forest, Washington, in 1974, remeasured in 1983 and 1989. R. Tinnin, Portland State University, assisted in the 1988 and 1989 remeasurements provided by the Rocky Mountain Station. References: Knutson and Tinnin (1986), Tinnin (1988, 1989).
 3. Apache-Sitgreaves, Carson, Lincoln, and Santa Fe National Forests (Arizona and New Mexico): study of permanent inventory plots to quantify Douglas-fir growth, mortality, and spread and intensification in unmanaged, mixed conifer stands; 54 plots with 216 Douglas-firs and 816 trees of other species. Plots first measured in 1977 and remeasured in 1987; remeasurement planned for 1997. Rocky Mountain Station. Reference: Geils and Shaw (in prep.).
 4. Apache-Sitgreaves National Forest, Arizona: 1,248 Douglas-fir trees tagged in 1979 in virgin mixed-conifer stands on the 1,800-acre Willow-Thomas Creek Watershed. Trees to be rerated for dwarf mistletoe in 1989. Rocky Mountain Station. Reference: Gottfried (1978).
 5. Wallowa-Whitman, Wenatchee, and Okanogan National Forests (Washington and Oregon): study of interaction of dwarf mistletoe and western spruce budworm on Douglas-fir growth, mortality, spread, and intensification in unmanaged stands—94 stands with 1,559

- Douglas-fir. Plots measured in 1977 and re-measured in 1987; remeasurement planned in 1997. Pacific Northwest Station; Forest Pest Management, Pacific Northwest Region; and Rocky Mountain Station. Reference: Filip et al. (in prep.).
6. Eastern Washington State Lands: 32 plots (0.1-acre) in even-aged pole stands. Most plots are in pure ponderosa pine but about one-fifth are mixed ponderosa pine-Douglas-fir. The Douglas-fir is also infected by dwarf mistletoe. Trees of both species were thinned and sanitized for dwarf mistletoe in 1974. Plots were remeasured in 1979 and in 1986. Ken Russell, Washington Department of Natural Resources, Olympia. References: Russell (1980, 1987).
- V. *ARCEUTHOBIUM ABIETINUM* ON WHITE FIR (*ABIES CONCOLOR*) AND RED FIR (*ABIES MAGNIFICA*)
1. Thinning plots in the Klamath, Lassen, Stanislaus, Tahoe, and Sequoia National Forests, California: 37 plots in white and red fir established in 1979–1981. Plots established by the Pacific Southwest Station and being maintained by the Pacific Southwest Region. References: none.
 2. California National Forests: 5, 100-tree plots to quantify dwarf mistletoe intensification and tree growth in fully released, advanced red fir 6–20 inches d.b.h. Plots established in 1972 on the Klamath, Lassen (2), Stanislaus, and Sierra National Forests. Pacific Southwest Station. References: none.
 3. Stanislaus National Forest, California: 3 plots (1 with 50 trees and 2 with 80 trees each) in cutover, released pole-sized red fir stands with dwarf mistletoe. Two plots established in 1970 and 1 in 1976. Pacific Southwest Station. References: none.
 4. Sierra Nevada, California: Plots with various numbers of trees established in 1958 on the Stanislaus National Forest and Latour State Forest (near Mt. Lassen) to quantify intensification of dwarf mistletoe in inoculated red and white firs. Pacific Southwest Station and University of California. Reference: Parmeter and Scharpf (1989).
- VI. *ARCEUTHOBIUM LARICIS* ON WESTERN LARCH (*LARIX OCCIDENTALIS*)
1. Growden Area, Colville National Forest, Washington: 40 plots (0.5-acre) in even-aged stands; 4 levels of dwarf mistletoe removal \times 5 thinning treatments \times 2 replicates. Established in 1970–73 by the Intermountain Station, remeasured in 1978, 1983, and 1988; 20-year results being analyzed by the Rocky Mountain Station. References: none.
 2. Coram Experimental Forest, Montana: 55 tagged western larch inoculated in a 15-year-old stand. Established in 1969 by the Intermountain Station; remeasured in 1978 and 1988; 20-year results are being analyzed at the Rocky Mountain Station. Reference: Wicker and Wells (1983).
3. Northeastern Oregon, Boise-Cascade Lands: study of the effects of commercial thinning on volume growth of dwarf mistletoe-infected larch; 554 western larch tagged in a stand near Elgin. Tree volumes were measured in 1970 and 1984; dwarf mistletoe and tree vigor (cambial electrical resistance) were measured in 1986. Pacific Northwest Station. Reference: Filip et al. (1989).
- VII. *ARCEUTHOBIUM TSUGENSE* ON WESTERN HEMLOCK (*TSUGA HETEROPHYLLA*)
1. Thorne Bay, Prince of Wales Island, Alaska: study on rate of spread and intensification of mistletoe from overstory residual western hemlocks into reproduction. In 1981, 19 plots (0.26 ha) established in reproduction of 2 age classes; plots were remeasured in 1983, 1985, and 1987; another examination is planned for 1990. Alaska Region, Juneau. References: Hennon and Shaw (1988), Shaw (1982), Shaw and Hennon (in prep.).
- VIII. *ARCEUTHOBIUM MICROCARPUM* ON ENGELMANN SPRUCE (*PICEA ENGELMANNII*) AND BLUE SPRUCE (*PICEA PUNGENS*)
1. Apache-Sitgreaves National Forest, Arizona: 554 Engelmann spruce and 67 blue spruce tagged in 1979 in virgin, mixed-conifer stands on the Willow-Thomas Creek Watershed. Trees were rated for dwarf mistletoe in 1989. Rocky Mountain Station. Reference: Gottfried (1978).

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